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Quantum-well curved-grating DBR laser structure

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Abstract. Theoretical investigation of the separate confinement single/multi quantum-well DBR laser with "curved-groove" diffraction gratings (c-DBR) is presented. Our calculations show that the proposed laser design provides both spectral selectivity of conventional DBR resonator and output beam focusing in the plane of p-n-junction. A comparison of the c-DBR and the c-DFB laser designs is also presented.

Recent advances in the technology of optoelectronic devices based on nano-sized heterostructures are opening up interesting avenues for research and enabling a wide range of new applications for laser diodes, notably in fields such as telecommunications and photomedicine. However, for most of these applications high-power single-frequency laser diodes with spatially controllable emission are required.

One approach to addressing this objective involving the design of a distributed feedback laser with a "curved-groove" diffraction grating (c-DFB) has already been introduced [1]. The use of a curved grating enables the combination of the high-power of a broad stripe device and spectral control provided by a diffraction grating together with output beam focusing in the plane of p-n-junction [2]. The main disadvantage of the distributed feedback structures is the requirement of subsequent regrowth of the grating structure within the pumping area. This additional technological process usually causes an increase in the internal losses and affects dramatically the yield of useful devices.

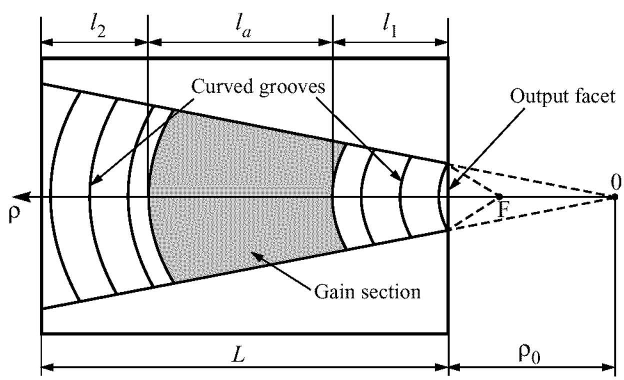

Fig. 1. A simplified schematic of the c-DBR laser.

To simplify the fabrication process required to produce the curved-grating laser diode a new type device is proposed. In this paper we describe a novel type of distributed Bragg reflector laser having a "curved-groove" diffraction grating (c-DBR). Figure 1 is a simplified schematic of such a c-DBR laser. This device also has the advantage of decreased internal

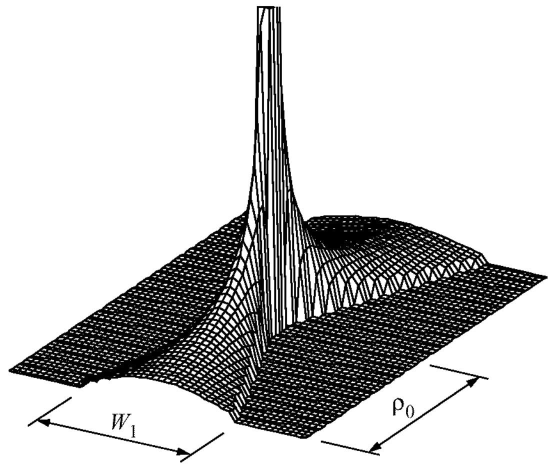

Fig. 2. The modelled performance of the c-DBR laser.

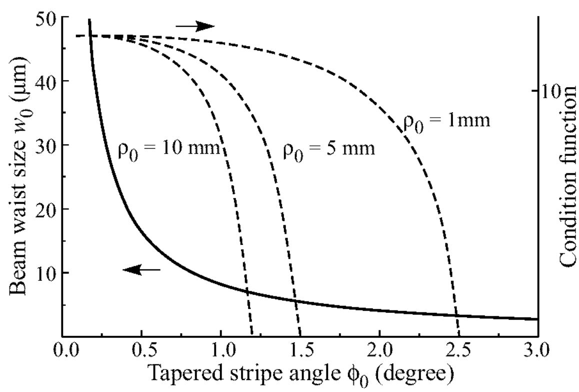

Fig. 3. Beam waist size w_0 versus the angular aperture ϕ_0 of the c-DBR laser in quasi-paraxial approximation (solid line). This quasi-paraxial condition is satisfied when the condition function (dashed line) is positive.

losses due to the replacement of the curved grating from the pumping area to the passive edge regions.

A diffraction grating with curved-grooves can be designed to concentrate the output emission to the focus determined by the curvature of the grating. Figure 2 shows the calculated far-field distribution in the plane of p-n-junction of a c-DBR laser for a single transverse mode operation. Laser beam focusing in the direction orthogonal to the plane of the p-n-junction can be obtained by the cylindrical lens mounted on the laser heat-sink. A comparison of the c-DBR and the c-DFB laser designs shows that the c-DBR laser offers the practical advantages of (i) simplified technology compared to c-DFB and (ii) improved "flexibility" of the design. This thus permits the laser to have beam properties that are compatible with different applications: In particular, the beam waist size external to the facet is significantly smaller than the emission aperture and the beam can be focused at a controllable distance from the exit facet without additional optics. A short focal length

is for example suitable for efficient optical coupling to a single-mode fibre or long focal length for pumping of gain or nonlinear crystals.

In summary, we have proposed a novel construction for a DBR laser having a "curved-groove" diffraction grating. The theoretical analysis shows that a laser with this novel construction can combine both the high-power of a broad stripe device and the spectral control provided by a diffraction grating together with exploitable beam focusing in the plane of p-n-junction.

References

[1] G. S. Sokolovskii, E. U. Rafailov, D. J. L. Birkin and W. Sibbett, *J. Opt. Quantum Electron.* **31**, 215 (1999).

[2] G. S. Sokolovskii, E. U. Rafailov, D. J. L. Birkin and W. Sibbett, *IEEE J. Quantum Electron.* **36**, 1412 (2000).